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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Apparatus for Detecting Carbon Monoxide

We, COAL INDUSTRY (PATENTS) LIMITED, a Company organised in accordance with the Laws of Great Britain, of Hobart House, Grosvenor Place, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for detecting carbon monoxide. Where the atmosphere to be tested includes oxygen, it can be passed over or through a catalyst, such as "Hopcalite," which causes combustion of the carbon monoxide. Burning of the carbon monoxide can however be brought about (even in the absence of atmospheric oxygen) by passing the atmosphere to be tested through an oxidising reagent, such as silver permanganate. In the present specification such catalysts and heat-producing oxidising reagents are collectively referred to as "oxidisers."

It is often of the greatest importance to detect carbon monoxide in an atmosphere and to obtain reliable and speedy warning if the concentration of carbon monoxide rises to a dangerous level, for example when a fire has occurred in mine workings or the like.

It has been proposed to provide such an apparatus comprising differential thermometric means used to ascertain the heat generated by the burning of carbon monoxide or other combustible gas or vapour in the said atmosphere by a catalytic or reactive agent, the apparatus being characterised in that the atmosphere being examined flows in two substantially identical streams through separate conduits of which one conduit contains one part of the differential thermometric means packed in a quantity of catalytic or reactive material whilst the other conduit contains the other part of the said differential thermometric means packed in a similar quantity of inactive material, the heat conductivity of, and the specific heat of the material in both conduits, being substantially the same. Likewise apparatus has been proposed in which the atmosphere being examined flows as a single stream over both parts of a differential thermometric means, one part being surrounded by an inert material and the other part by an oxidiser.

One object of the present invention is to provide an improved portable apparatus of increased reliability.

According to the invention apparatus for the detection of carbon monoxide in an atmosphere comprises differential thermometric means which includes a thermistor juxtaposed with an oxidiser and another thermistor juxtaposed with an inert material, the oxidiser and the inert material being subjected to the atmosphere to be tested, and an electric circuit in which the thermistors are connected, which circuit is adapted to produce a signal indicative of the difference in temperature of the thermistors.

The invention is illustrated by way of example in the drawing which accompanied the provisional specification, where Figs. 1 and 2 show one arrangement of the differential thermometric means and an electric circuit respectively. The invention is further illustrated by the accompanying drawings in which Figure 3 is a side sectional elevation of the preferred construction of differential unit;

Figure 4 is a view of the complete gas flow system; and

Figure 5 is a connection diagram of a convenient amplifier and electrical system.

In the relatively simple arrangement shown in Figure 1, the atmosphere to be tested is drawn in by a diaphragm pump 1 operated by an electrically driven solenoid unit 1*a*. The output from the pump is passed through a drying chamber 2 containing desiccating material and then flows along a reaction tube 3 in which are mounted two thermistor units 4, 5 of the well-known type comprising a small bead of thermistor material mounted within the lower end of a sealed glass bulb, a pair of electrical leads being brought out

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through the upper end of each unit for connection in a testing circuit as will be hereinafter explained. The temperature sensitive end of the thermistor unit 5 is surrounded by a mass 6 of oxidiser material which may be a catalyst. This material produces partial or complete oxidation of any carbon monoxide in the atmosphere passing through the reaction tube 3. It is a feature of this invention that partial oxidation is used to produce desirable response characteristics, for example, the concentration of carbon monoxide indicated by the apparatus is independent of the rate of flow of the atmosphere within certain limits through the reaction tube 3. Convenient materials for this purpose are silver permanganate as chemical reagent, or the material known commercially as "Hopcalite" as a catalytic reagent.

The oxidation of the carbon monoxide results in a rise of temperature of the mass 6, and the electrical resistance of the thermistor unit 5 accordingly falls as the temperature rises.

In order to compensate for variations in the operating conditions, such as changing ambient temperature, the lower end of the thermistor unit 4 is surrounded by inert material having substantially the same specific heat and thermal insulating properties as the oxidiser mass 6. Thus changes in ambient temperature affect both thermistor units 4 and 5 equally, but only the unit 5 is affected by combustion of any carbon monoxide in the mass 6. A drying chamber 7 is connected to the outlet end of the reaction tube 3 and has a free escape vent tube 8, the desiccating material in the drying chamber 7 serving to prevent atmospheric moisture reaching the oxidiser mass 6 when the pump 1 is not working.

Referring to Figure 2, the circuit comprises two thermistors 4 and 5 arranged with two resistors 11 to form a wheatstone bridge which can be balanced by a potentiometer 12. The circuit is fed with current from a high tension battery 13 and a low tension battery 14. The potentiometer 12 is used to balance the bridge until the out of balance voltage is zero with both thermistors at the same temperature. The bridge is supplied with current from an oscillator valve 15 by means of the third winding on a transformer 16, and any out of balance voltage from the bridge is fed between the grid and cathode of an amplifying valve 17 having an anode load inductance 18. The output from this stage is fed between the grid and cathode of a second amplifying valve 19. A potentiometer 20 controls the sensitivity of the instrument. The valve 19 has an anode load inductance 21 and the output from this stage is fed to two rectifiers 22 of which one acts as a D.C. restorer, and the other charges a condenser between the grid and cathode of an output valve 23. When the bridge is balanced anode current flows in the output valve 23 and operates a relay 24, the anode current being measured on a meter 25. A variable resistor 26 is used to set the meter to zero when the thermistors are at the same temperature. If the bridge be unbalanced by heating of one thermistor by the catalyst the out of balance voltage is amplified, causing the condenser between the grid and cathode of the valve 23 to become negatively charged and reducing the anode current shown by the meter 25, thus the meter reading depends upon the amount of carbon monoxide oxidised. Upon the anode current being sufficiently reduced, the relay 24 is de-energised and its contacts close the circuits of a warning lamp 27 and buzzer 28. A push button 29 can be operated to short-circuit the meter 25 and resistor 26 and so fully energise the relay 24, this being done in setting the instrument and resetting after the alarm has operated. The circuit is provided with an indicator lamp 30, switches 32 and appropriate resistances and condensers, and the vibrator pump 31 is connected in the circuit as shown.

In practice it is found that more accurate and reliable results can be obtained with the construction of reaction device shown in Figure 3. The reaction tube 3 comprises a cylindrical block 40 of thermal insulating material, such as expanded ebonite, formed with an axial passage 41 having enlarged end portions 42 and 43. A pair of wire gauze screens 44 are fitted into the enlarged portion 42 and the space between is filled with inert material 45 through which the atmospheric gas to be tested can pass. The thermistor unit 4 extends into the material 45 so as to be responsive to temperature changes therein. Similarly spaced screens 46 are fitted into the enlarged portion 43 of the passage and the intervening space is filled with the mass 6 of "Hopcalite" or other suitable oxidiser material, the sensitive end of the thermistor unit 5 being buried in this material. The reaction tube 3 is fitted inside a barrel 47 made of good heat-conducting material, such as copper or brass, and this is surrounded by a helical pipe coil 48, the turns of which are preferably soldered to the barrel. That end 49 of the coil nearest the active material 6 forms the inlet for gas to be tested, while the other end 50 of the coil passes through the barrel 47 into an antechamber 51 formed by a plug 52 closing the end of the barrel 47; the other end is fitted with a plug 53 in which a gas exit pipe 54 is provided. The barrel 47 and pipe coil 48 are surrounded by a jacket 56 of cotton wool or other material having good heat insulating properties, and this is provided with a protective outer casing 55. The provision of the barrel 47 and the coil 48, both of which are good conductors of heat, ensures that any changes of temperature occurring in the surrounding atmosphere are trans-

mitted substantially equally to the two thermistor units 4 and 5, and therefore do not affect the accuracy of the instrument; moreover the parts 47, 48 act as a heat exchanger or heat "sink" ensuring that the temperature of the air by the time it reaches the antechamber 51 and inert mass 45 is substantially equal to that of the air in the passageway 41 and oxidiser mass 6. Nevertheless the expanded ebonite block 3 provides sufficient insulation to allow the temperature of the oxidiser mass 6 to rise as a result of combustion therein.

In practice it is found that the mere abstruction of water vapour from the air to be tested is not sufficient, especially in coal mines, as the atmosphere may contain substances which affect the operation of the oxidiser. A suitable chemical purifier system is shown, therefore, in Figure 4. Upon the inlet 57 of the pump 1 a filter unit 58 containing cotton wool is provided to take out solid particles. The delivery pipe 59 of the pump leads into a vessel 60 containing mercuric sulphate and magnesium sulphate and sulphuric acid impregnated on silica gel. This removes unsaturated hydrocarbon vapours. If desired bromine in active charcoal may be used. A pipe 61 then leads to a second vessel 62 containing soda lime or soda asbestos for removing water vapour and acidic gases generally. The outlet 63 passes to a selector valve 64 conveniently of the plug type with two passages in the plug as shown. In normal use the pipe 63 is connected to the inlet 65 of a third vessel 66 containing anhydrous magnesium perchlorate (usually known as "Anhydrone") for removing water vapour and ammonia gas. The purified gas then passes by way of pipe 67 to the inlet 49 of the reaction unit which is indicated at 68 and is of the construction shown in Figure 3. The gas exit pipe 54 is connected to a drying chamber 7 as in the previous example, the final outlet being shown at 8.

The valve 64, when turned through 90° from the normal position shown, connects pipe 63 with the inlet pipe 69 of a vessel 70 filled with active granular "Hopcalite," the outlet pipe 71 then leading the gas through the pipe 65 into the vessel 66. Thus as the gas flows through the "Hopcalite" in the vessel 70 any carbon monoxide present in it is oxidised, so that the gas reaching the reaction unit 68 is absolutely free of carbon monoxide. This is very useful for enabling the indicating portion of the apparatus to be tested and/or calibrated, more particularly with regard to the zero reading.

If desired, in either of the two examples given, more than one pair of thermistor units may be used to obtain a stronger signal of the presence and concentration of carbon monoxide.

A convenient arrangement for the amplifier, indicator and electrical system is shown in Figure 5 and in this diagram, thermistor units 4 and 5 are connected as arms of a Wheatstone bridge including also a pair of resistors 103 and a potentiometer 104 for balancing.

The circuit is fed with power from a high tension battery 105 and a low tension battery 106. The potentiometer 104 is used to balance the bridge until the out-of-balance voltage is zero with both thermistors at the same temperature. The bridge is fed with alternating current from an oscillator valve 107 by means of a third winding on a transformer 108. Any out-of-balance voltage from the bridge is fed between the grid and cathode of an amplifying valve 109 having an anode load inductance 110. The output from this stage is fed between grid and cathode of a second amplifying valve 111. A potentiometer 112 controls the sensitivity of the instrument. The valve 111 has an anode load inductance 113 and the output from this stage is fed to two rectifiers 114 of which one acts as a D.C. restorer and the other charges a condenser 125 between the grid and cathode of an output valve 115. When the bridge is balanced, anode current flows in the output valve 115 and operates a relay 116 to open contacts 116*a*, the anode current being measured by a meter 117. A variable resistor 118 is used to set the meter to full scale deflection (actually marked zero on the CO scale) when the thermistors are at the same temperature.

If the bridge be unbalanced by the heating of one thermistor by the combustion of carbon monoxide, the out-of-balance voltage is amplified, causing the condenser between the grid and cathode of the valve 115 to become negatively charged, and reducing the anode current shown by the meter 117. Thus the meter reading depends upon the amount of carbon monoxide oxidised, and when equilibrium is reached, the deflection of the meter indicates the carbon monoxide concentration.

Upon the anode current being sufficiently reduced, the relay 116 is de-energised and its contacts close the circuits of a warning lamp 119 and buzzer 120.

In the circuit shown in Figure 5, the change in anode current of valve 115 depends upon the change in temperature produced in the reaction chamber. The time taken before the anode current of valve 115 is reduced sufficiently to de-energise the relay 116 and operate the alarms, therefore, depends upon the time taken for the temperature to rise high enough to unbalance the bridge sufficiently for this to occur. The higher the carbon monoxide concentration, the shorter this time will be.

If desired, however, a differentiating circuit of suitable time constant, such as that shown in dotted lines at 126, may be interposed between the condenser 125 and the grid of

valve 115, in which case the change in the anode current of valve 115 may be made wholly or partly dependent upon the rate of change of temperature in the reaction chamber.

The differentiating circuit does not affect the operation of the meter 117 which still records the carbon monoxide concentration, once equilibrium has been reached. A push-button 121 can be operated to short-circuit the meter 117 and resistor 118 to fully energise the relay 116, this being done in setting the instrument and resetting after the alarm has operated.

The circuit is provided with an indicator lamp 122, switches 124 and appropriate resistors and condensers and the electric pump 123 is connected in the circuit as shown, the interrupter contacts being indicated at 123a (Fig. 5). The switch 127 is provided with appropriate resistors so that the voltages of the high tension and low tension batteries may be checked by means of the meter 117 connected as a voltmeter.

What we claim is:—

1. Apparatus for the detection of carbon monoxide in an atmosphere, comprising differential thermometric means which includes a thermistor juxtaposed with an oxidiser and another thermistor juxtaposed with an inert material, the oxidiser and the inert material being subjected to the atmosphere to be tested, and an electric circuit in which the thermistors are connected, which circuit is adapted to produce a signal indicative of the difference in temperature of the thermistors.

2. Apparatus for the detection of carbon monoxide in an atmosphere comprising differential thermometric means which includes at least one pair of thermistors, one thermistor of each pair being juxtaposed with an oxidiser and the other thermistor of each pair being juxtaposed with an inert material, the oxidiser and inert material being so contained in a duct as to be in a series relation to a flow of atmosphere to be tested through the duct, and means electrically connecting the thermistors to indicate the difference in temperature between the thermistor(s) juxtaposed with the inert material and the thermistor(s) juxtaposed with the oxidiser.

3. Apparatus as claimed in claim 2 wherein the thermistors are connected to an amplifying device which is responsive to changes in the difference between the resistance value of the thermistor units, the output from the amplifier device being caused to give a signal and/or an indication representing the quantity of carbon monoxide in the atmosphere being tested.

4. Apparatus as claimed in claim 2 or 3 wherein the duct is formed in a member having poor heat conducting properties.

5. Apparatus as claimed in any one of claims 2 to 4 in which means of good heat conducting properties are disposed around the duct so that changes in the temperature of the surrounding atmosphere are transmitted substantially equally to both thermistors.

6. Apparatus as claimed in claim 5 in which the heat conducting means comprises a tubular barrel around the duct.

7. Apparatus as claimed in claim 5 or 6 in which the heat conducting means comprises a heat reservoir whereby the temperature of the atmosphere when it enters the duct is substantially equal to that of the atmosphere already in the duct.

8. Apparatus as claimed in claim 7 in which the heat reservoir comprises a helically coiled tube closely surrounding the barrel and through which the atmosphere passes before entering the duct.

9. Apparatus as claimed in claim 8 wherein the helically coiled tube is bonded to the barrel, as by soldering, thereby increasing the heat conductivity from one part to the other.

10. Apparatus as claimed in any preceding claim, wherein a pretreating vessel containing oxidiser is included in the apparatus and is adapted to be connected to act upon the stream of atmosphere before said stream reaches the mass of oxidiser associated with the thermometric means, said pre-treating oxidiser providing a stream free of carbon monoxide for use in testing the zero operation of the apparatus.

11. Apparatus as claimed in claim 10, wherein a selector valve is provided in connection with the pre-treating vessel, said valve being arranged to isolate the pre-treating vessel entirely from the stream during normal operation of the apparatus.

12. Apparatus for the detection of carbon monoxide substantially as described with reference to the figures of the drawings which accompanied the Provisional Specification.

13. Apparatus for the detection of carbon monoxide substantially as described with reference to the figures of the accompanying drawings.

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Chartered Patent Agent.

PROVISIONAL SPECIFICATION

Apparatus for Detecting Carbon Monoxide

We, COAL INDUSTRY (PATENTS) LIMITED, a Company organised in accordance with the laws of Great Britain of Hobart House, Grosvenor Place, London, S.W.1., do hereby declare this invention to be described in the following statement:—

This invention relates to apparatus for detecting carbon monoxide in an atmosphere including oxygen.

It is often of the greatest importance to detect carbon monoxide in an atmosphere and to obtain reliable and speedy warning if the concentration of carbon monoxide rises to a dangerous level, for example when a fire has occurred in mine workings or the like.

It has been proposed to provide such an apparatus comprising differential thermometric means used to ascertain the heat generated by the burning of carbon monoxide or other combustible gas or vapour in the said atmosphere by a catalytic or re-active agent, the apparatus being characterised in that the atmosphere being examined is flowing in two substantially identical streams through separate conduits of which one conduit contains one part of the differential thermometric means packed in a quantity of catalytic or re-active material whilst the other conduit contains the other part of the said differential thermometric means packed in a similar quantity of inactive material, the heat conductivity of, and the specific heat of the material in both conduits, being substantially the same.

One object of the present invention is to provide an improved portable apparatus of increased reliability.

According to the invention an apparatus for the detection of carbon monoxide in an atmosphere including oxygen, comprising differential thermometric means for ascertaining the heat generated by the burning of the carbon monoxide in the atmosphere by a catalytic agent is characterised in that the atmosphere being examined is caused to flow in a single stream over both parts of the differential thermometric means, both these parts being arranged similarly in all respects except that one is surrounded by inert material and the other is surrounded by an active catalytic agent. The parts of the thermometric means may be thermistors, and in a preferred embodiment a matched pair of thermistors are arranged in opposite arms of a Wheatstone bridge so that when the resistance of the thermistor surrounded by the catalyst is lowered by heat from the oxidation of carbon monoxide the bridge is unbalanced, the degree of unbalance depending upon the amount of heat produced and therefore upon the rate of burning of carbon monoxide. Any suitable means may be employed for detecting an excessive lack of balance in the bridge and/or indicating the amount of any lack of balance, but it is preferred to use an amplifying circuit, preferably employing four thermionic valves. An electrically operated vibrator pump may be used for passing the atmosphere through suitable drying and/or filtering devices and thence over the catalyst and the two parts of the differential thermometric means, and the apparatus may also incorporate electrically operated warning means such as lamps or buzzers which are actuated upon the concentration of carbon monoxide rising above a predetermined level.

By way of example an apparatus according to the invention is illustrated in the accompanying drawings, in which

Figure 1 shows the arrangement of the differential thermometric means, and

Figure 2 is a circuit diagram.

Referring to Figure 1, the atmosphere is drawn in by a diaphragm pump 1 and passed through a drying chamber 2 to a re-action tube 3 in which are mounted two thermistors 4 and 5. The thermistor 5 is surrounded at its lower end by catalyst 6 (for example hopcalite) and the lower end of the thermistor 4 is surrounded by inert catalyst or glass wool or some other material which has similar thermal insulating properties to those of the catalyst 6. From the re-action tube 3 the gas passes through a drying chamber 7 to a vent 8, the chamber 7 serving to prevent moisture moving back to the catalyst 6 when the pump is not acting.

Referring to Figure 2, the circuit comprises two thermistors 4 and 5 arranged with two resistors 11 to form a wheatstone bridge which can be balanced by a potentiometer 12. The circuit is fed with current from a high tension battery 13 and a low tension battery 14. The potentiometer 12 is used to balance the bridge until the out of balance voltage is zero with both thermistors at the same temperature. The bridge is supplied with current from an oscillator valve 15 by means of the third winding on a transformer 16, and any out of balance voltage from the bridge is fed between the grid and cathode of an amplifying valve 17 having an anode load inductance 18. The output from this stage is fed between the grid and cathode of a second amplifying valve 19. A potentiometer 20 controls the sensitivity of the instrument. The valve 19 has an anode load inductance 21 and the output from the stage is fed to two rectifiers 22 of which one acts as a D.C. restorer, and the other charges a condenser between the grid and cathode of an output valve 23. When the bridge is balanced anode current flows in the output valve 23 and operates a relay 24, the anode current being measured on a meter 25. A variable resistor

26 is used to set the meter to zero when the thermistors are at the same temperature. If the bridge be unbalanced by heating of one thermistor by the catalyst the out of balance voltage is amplified, causing the condenser between the grid and cathode of the valve 23 to become negatively charged and reducing the anode current shown by the meter 25, thus the meter reading depends upon the amount of carbon monoxide oxidised. Upon the anode current being sufficiently reduced, the relay 24 is de-energised and its contacts close the circuits of a warning lamp 27 and buzzer 28. A push button 29 can be operated to short-circuit the meter 25 and resistor 26 and so fully energise the relay 24, this being done in setting the instrument and resetting after the alarm has operated. The circuit is provided with an indicator lamp 30, switches 32 and appropriate resistances and condensers, and the vibrator pump 31 is connected in the circuit as shown.

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756,662 PROVISIONAL SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale.*

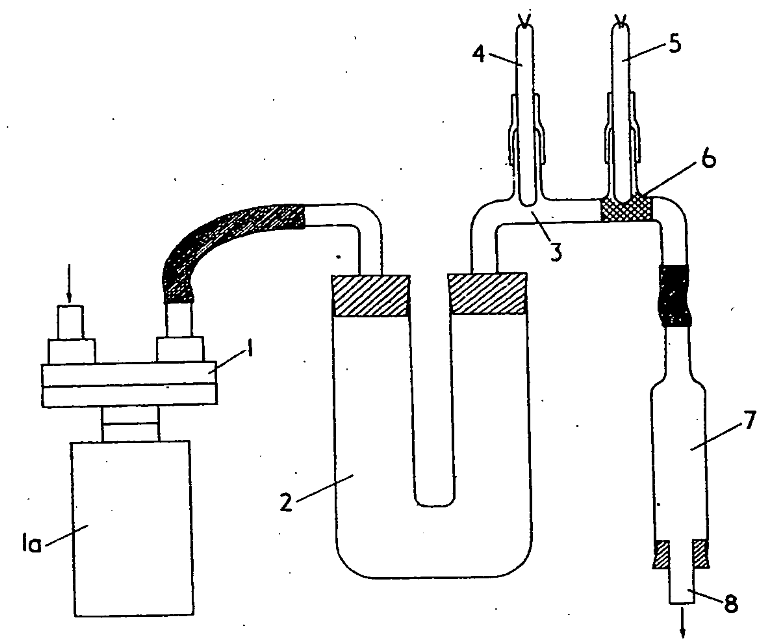

FIG. 1.

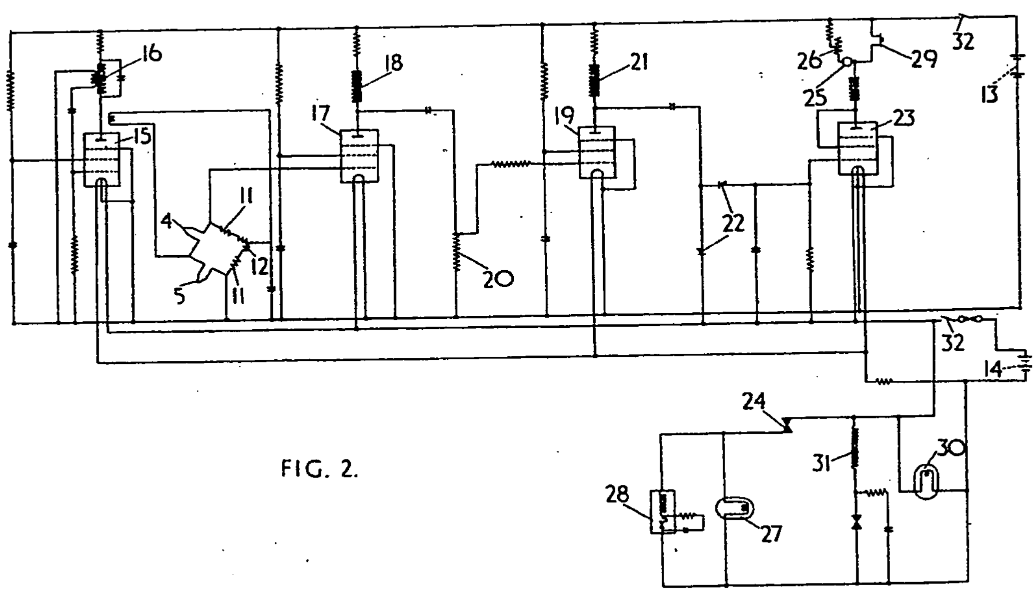

FIG. 2.

756,662 COMPLETE SPECIFICATION

1 SHEET

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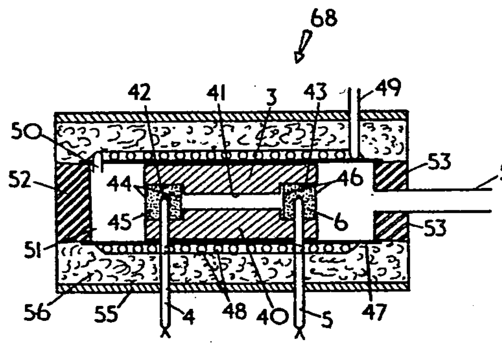

FIG. 3.

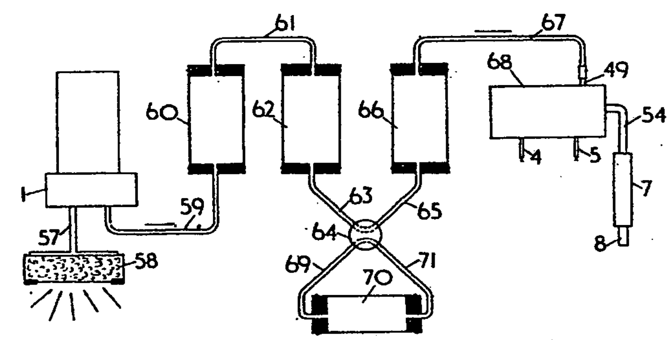

FIG. 4.

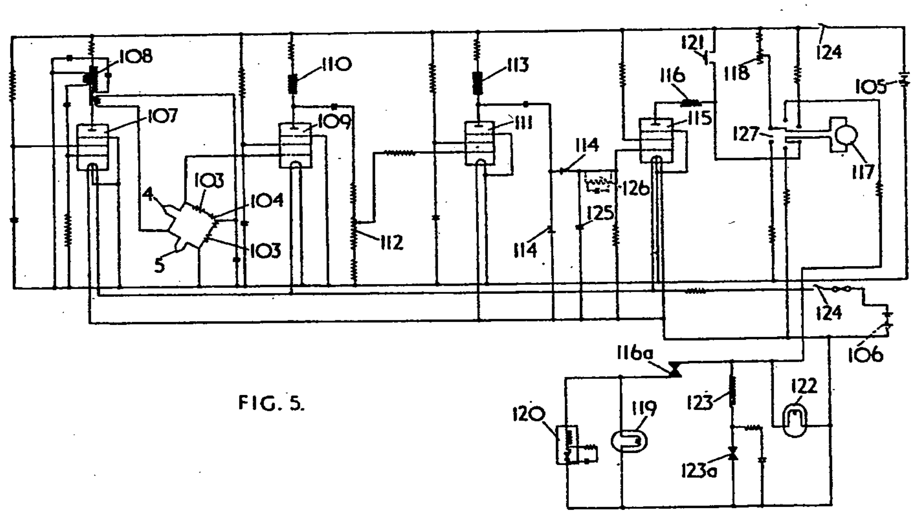

FIG. 5.